Fire Research Laboratory
BUREAU OF ALCOHOL, TOBACCO, FIREARMS AND EXPLOSIVES
6000 Ammendale Road
Beltsville, MD 20705-1250
Phone: 202-648-6200

U. S. Department of Justice

Test record

ASCLD/LAB–*International* Testing Accreditation Certificate ALI-217-T

Title	Burning Box and Sofa		
Test Type	Research		
Lab Number	ATFFRL040004		
Test dates	9/24/04, 9/27/04	**No. Tests**	2

Thermocouples

Thermocouples are temperature measurement sensors that consist of two dissimilar metals joined at one end (a junction) that produces a small thermo-electrical voltage when the wire is heated. The change in voltage is interpreted as a change in temperature [1]. There are many configurations of thermocouples which affect the temperature range, ruggedness, and response time. The information required to identify these factors for the thermocouples that were used during the experiment(s) conducted for this test series is provided in the “Thermocouple Measurement Description” table. Thermocouples used during this test series were used in accordance with the method defined in FRL laboratory instruction “LI001 Thermocouple” [2].

The following table provides a description of the instrumentation used to collect the temperature measurements during the experiments. The "Description" column describes the location of the temperature measurement. The "Thermocouple Type" describes the characteristics of the thermocouple used.

Table 1. Thermocouple Measurement Description

Description	Thermocouple type
0.615 meter above box	Type K, Inconel, 3mm dia
0.6 meter above box	Type K, Inconel, 3mm dia
half height of sofa	Type K, Inconel, 3mm dia

Heat Flux Transducers

A heat flux transducer is a device that measures the rate of absorbed incident energy, and expresses it on a per unit area basis. The operating principle of the Schmidt-Boelter heat flux transducer(s) used during this test series is based on one-dimensional heat conduction through a solid. Temperature sensors are placed on a thin, thermally conductive sensor element, and applying heat establishes a temperature gradient across the element. The heat flux is proportional to the temperature difference across the element according to Fourier’s Law [3].

There are many configurations of heat flux transducers which affect range, size, mode and sensitivity. The information required to identify these factors for the heat flux transducer(s) that were used during the experiment(s) conducted for this test series is provided in the “Heat Flux Measurement Description” table. Heat flux transducers were used in accordance with the method defined in FRL laboratory instruction “LI002 Heat Flux Transducer” [4].

The following table provides a description of the transducer used to collect heat flux measurements during the experiment(s). The “Description” column typically describes the location of the heat flux transducer. Heat flux mode indicates whether the total heat flux was measured or just the radiation fraction.

Table 2. Heat Flux Measurement Description

Description	Heat Flux Mode
1 meter away	Total
2 meters away	Total
2 meter away	Total
1 meters away	Total

Fire Products Collector

A Fire Products Collector (FPC) measures several characteristics of a fire based upon the measured properties of the fire plume. A FPC consists of a collection hood connected to an exhaust duct placed over a fire as shown in Figure 1. The primary fire characteristics calculated from a FPC include heat release rate (HRR), convective heat release rate (CHRR), gas species production, and smoke production. HRR measurements are based on the principle of oxygen consumption calorimetry. CHRR is calculated as the enthalpy rise of gases flowing through the FPC. Gas species production is calculated based on the measured gas concentrations flowing through the FPC. Smoke production is quantified based on optical smoke measurements, which measure the attenuation of light as it passes through the smoke and fire gases in the FPC.

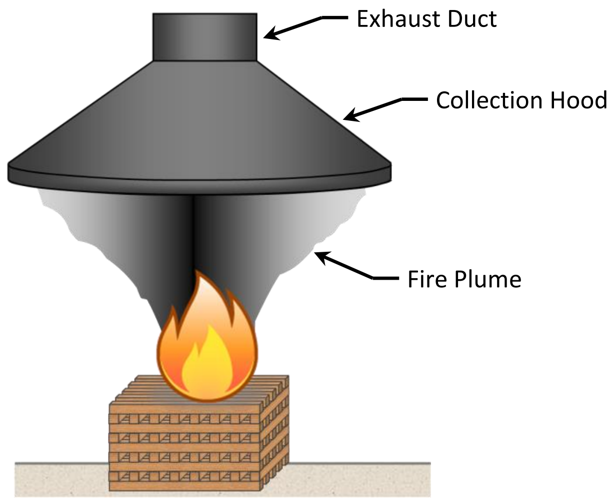

Figure 1. Schematic of a Fire Products Collector

The “Fire Products Collector Description” table identifies which FPC was used in the experiment(s) and summarizes the configuration. Fire Products Collectors were used in accordance with the method defined in FRL Laboratory Instruction “LI011 Fire Products Collectors” [5].

The following table provides a description of the FPC used in the experiment(s). The table includes a description of the FPC, as well as the Calibration factor (C Factor) and E values, which are used to calculate the HRR during an experiment. The C Factor is based on data from a fire with a known HRR. E is the net heat released per unit of oxygen consumed, a property of the fuel being burned.

Table 3. Fire Products Collector Description

Description	C Factor	E (kJ/kg)
1 MW Square	0.9556	13.1

Experiment Photographs

Digital Cameras are used within the FRL to record digital still photographs during experiments. Digital Cameras used during this test series were used in accordance with the method defined in FRL Laboratory Instruction “LI003 Digital Cameras” [6].

Results for Test 1 (ID 708)

The following table provides a summary of the temperature results. The “Initial” column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the “Max” column. The remaining columns provide the calculated maximum average temperatures.

Table 4. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
0.615 meter above box	24	32769	32769	32769	32769	32607

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

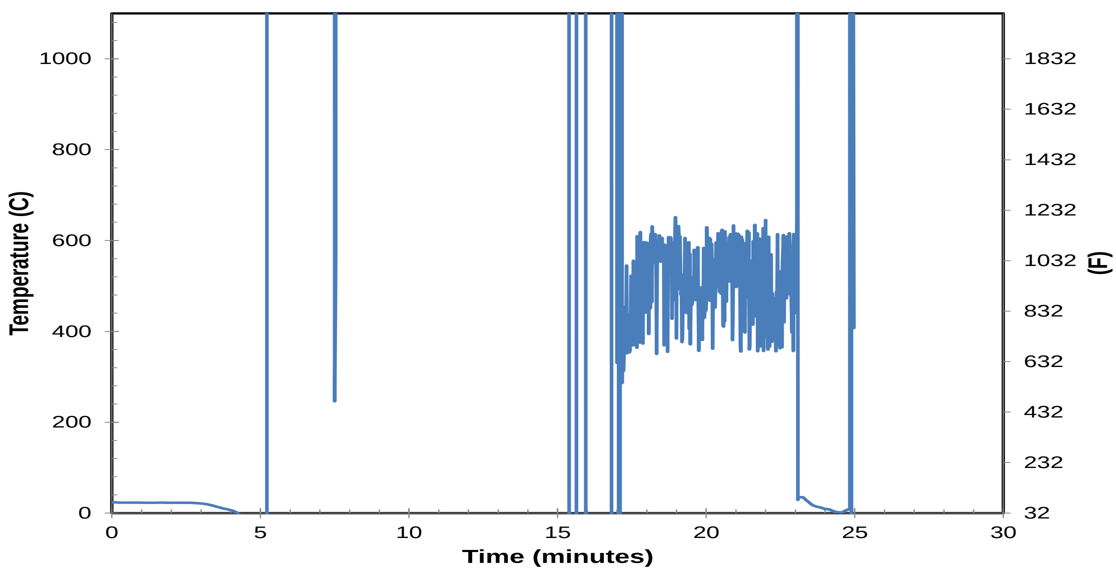

Figure 2. Temperature

The following table provides a summary of the heat flux results. The “Description” column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the “Time of Initial Change” column. The pre-determined amount of change in heat flux is provided in the “Initial Change Amount” column. The maximum heat flux recorded during the test is provided in the “Maximum” column. The “Maximum Average” columns are calculated over four pre-determined time spans.

Table 5. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
1 meter away	0	5	2.7	2.5	2.4	2.2	1.9
2 meters away	0	5	6.5	6.2	6	5.8	5.3

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

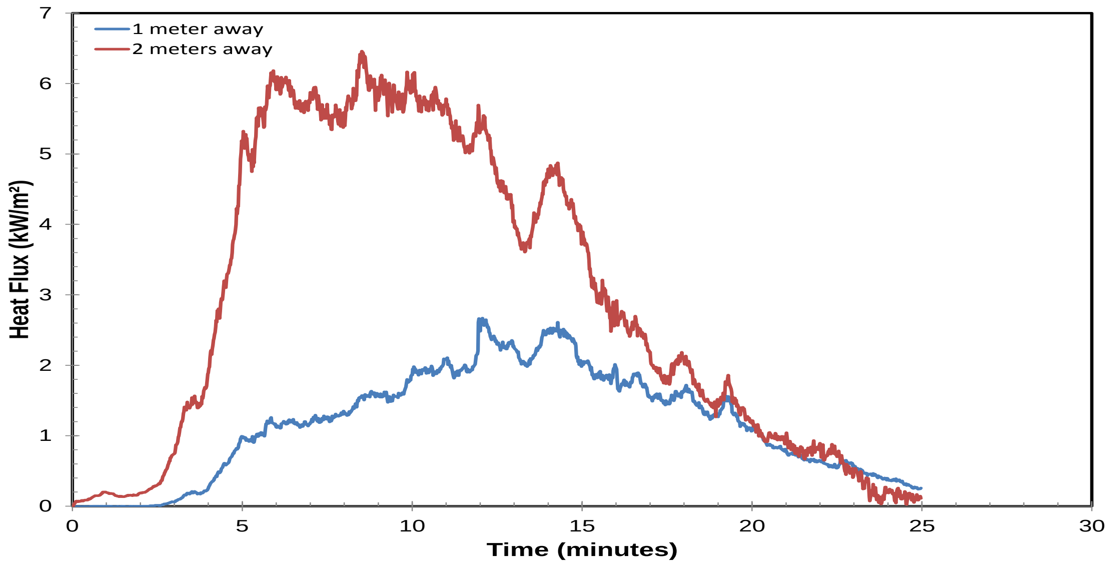

Figure 3. Heat Flux

The following figures show all of the still photographs uploaded into the FireTOSS system. The caption below each figure provides the picture's filename as well as any description and elapsed test time associated with the picture.

Figure 4. PRE, 20040924153786

Figure 5. PRE, 2004092415377

Figure 6. PRE, 200409241537658

Figure 7. PRE, 200409241537539

Figure 8. 47, 20040924153720

Figure 9. 151, 200409241537571

Figure 10. 245, 200409241537252

Figure 11. 319, 200409241537652

Figure 12. 377, 20040924153793

Figure 13. 513, 200409241537573

Figure 14. 530, 2004092415374

Figure 15. 620, 200409241537465

Figure 16. 730, 200409241537825

Figure 17. 1,068, 200409241537276

Results for Test 1 (ID 710)

The following table provides a summary of the temperature results. The "Initial" column provides the measured temperature at the beginning of the test. The maximum temperature recorded during the test is provided in the "Max" column. The remaining columns provide the calculated maximum average temperatures.

Table 6. Temperature Value Result Summary

Description	Initial (C)	Max (C)	30 second maximum average (C)	60 second maximum average (C)	300 second maximum average (C)	600 second maximum average (C)
0.6 meter above box	23	671	609	551	254	0
half height of sofa	23	784	760	707	428	0

The following chart(s) present a time-dependent representation of the instantaneous temperatures measured during the experiment.

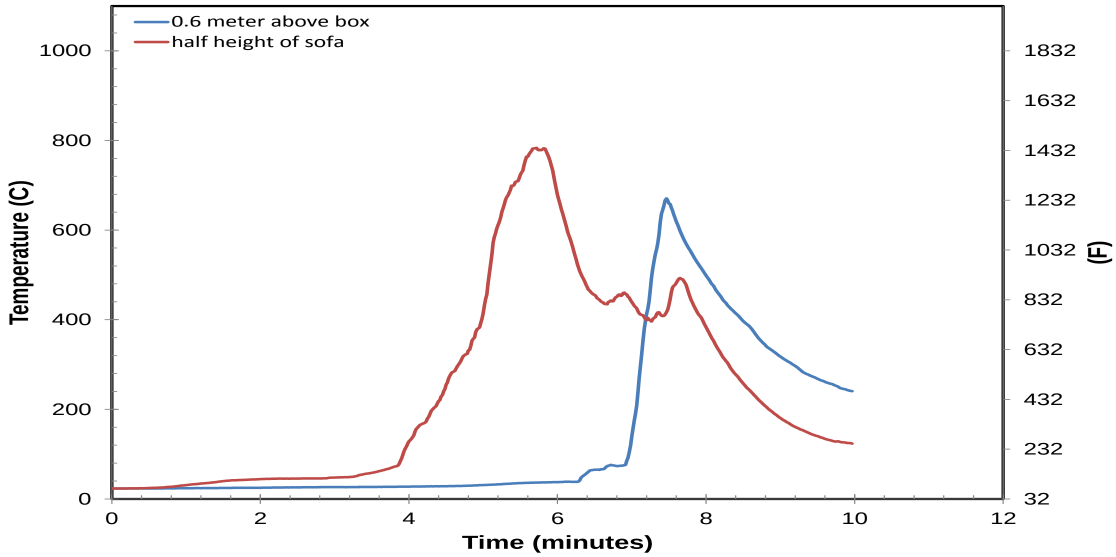

Figure 18. Temperature

The following table provides a summary of the heat flux results. The "Description" column typically describes the location of the heat flux transducer. The time at which the heat flux first changes by a pre-determined amount is provided in the "Time of Initial Change" column. The pre-determined amount of change in heat flux is provided in the "Initial Change Amount" column. The maximum heat flux recorded during the test is provided in the "Maximum" column. The "Maximum Average" columns are calculated over four pre-determined time spans.

Table 7. Heat Flux Result Summary

Description	Time of Initial Change (s)	Initial Change Value (kW/m²)	Maximum (kW/m²)	30 second maximum average (kW/m²)	60 second maximum average (kW/m²)	300 second maximum average (kW/m²)	600 second maximum average (kW/m²)
2 meter away	0	5	5.9	5.5	5.2	3.8	0
1 meters away	0	5	10.7	9.9	9.4	7.2	0

The following chart shows a time dependent representation of the instantaneous heat flux measured during the experiment.

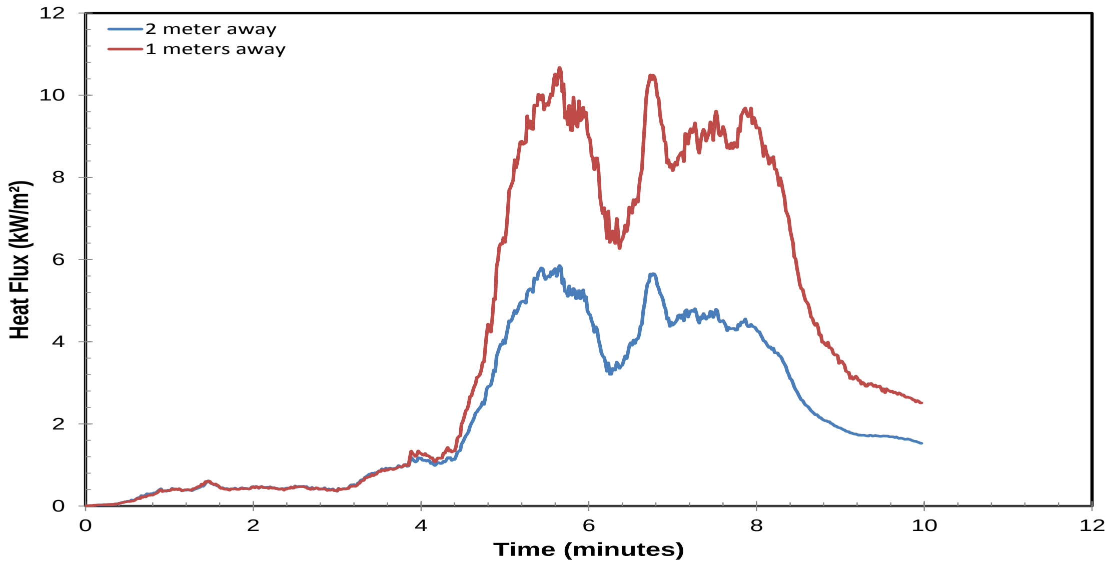

Figure 19. Heat Flux

The following figures show all of the still photographs uploaded into the FireTOSS system. The caption below each figure provides the picture's filename as well as any description and elapsed test time associated with the picture.


Figure 20. PRE, 200409271515256


Figure 21. PRE, 200409271515247


Figure 22. 4, 200409271515678


Figure 23. 15, 200409271515998


Figure 24. 23, 200409271515519


Figure 25. 63, 200409271515919


Figure 26. 71, 200409271515480


Figure 27. 87, 200409271515851


Figure 28. 295, 200409271515323

Results Summary

The following chart shows the heat release rate of the fire during the experiment. The heat release rate is calculated based on the principle of oxygen consumption calorimetry.

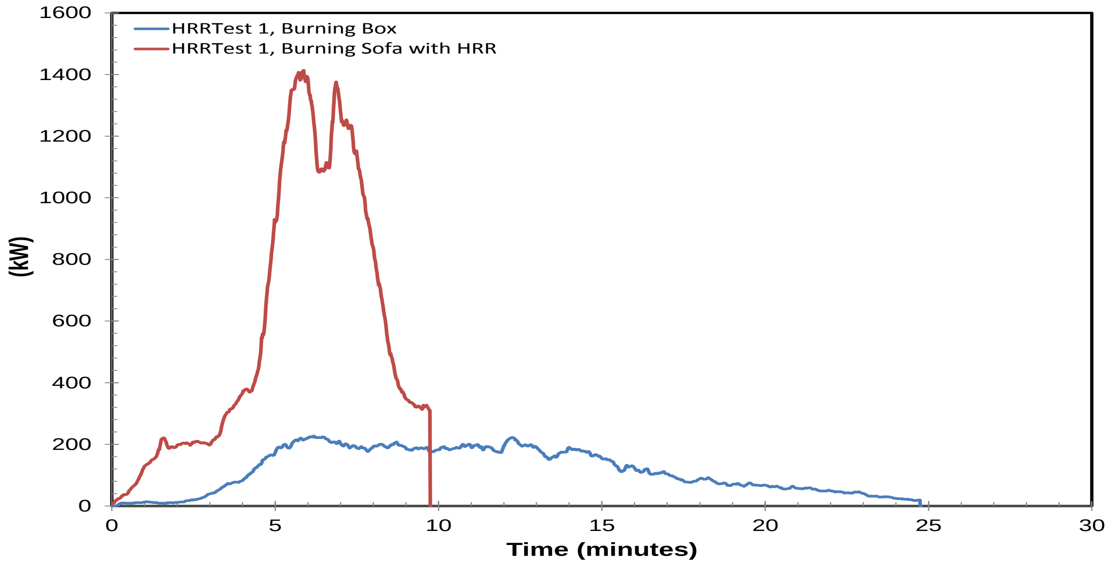

Figure 29. Heat Release Rate

References

1. The Temperature Handbook, 2nd edition, Omega Engineering, Stamford, CT, 2000.
2. Laboratory Instruction LI001 - Thermocouple, Bureau of Alcohol, Tobacco, Firearms and Explosives – Fire Research Laboratory, Beltsville, MD.
3. Barnes, A., "Heat Flux Sensors Part 1: Theory," Sensors, January 1999.
4. Laboratory Instruction LI002 - Heat Flux Transducer, Bureau of Alcohol, Tobacco, Firearms and Explosives - Fire Research Laboratory, Beltsville, MD.
5. Laboratory Instruction – Fire Products Collectors – LI011, Bureau of Alcohol, Tobacco, Firearms and Explosives – Fire Research Laboratory, Beltsville, MD.
6. Laboratory Instruction LI003 - Digital Cameras, Bureau of Alcohol, Tobacco, Firearms and Explosives - Fire Research Laboratory, Beltsville, MD